Search for Higgs boson pair production in 2b + 2ℓ + E_T^{miss} final states in pp collisions at $\sqrt{s}$ = 13 TeV with the ATLAS Experiment and Module Testing of the ATLAS Inner Tracker (ITK)

Abstract

Since the discovery of the Higgs boson by the ATLAS and CMS collaborations at the Large Hadron Collider (LHC) in 2012, intense efforts have been devoted by the particle physics community to studying its properties, and comparing them to the predictions of the Standard Model (SM), including the couplings of the Higgs boson to itself and to other particles. The Higgs self-coupling can be measured directly in the Higgs pair production (HH) process, and will provide insight into the nature of electroweak symmetry breaking. In the SM, the di-Higgs cross section in proton-proton collisions is very small. However, a wide range of beyond-the-SM models predict enhancements to the di-Higgs production rate, which motivates searching for di-Higgs production even now, when the SM cross section is too small to measure in the current LHC dataset.

The HH to bbll analysis investigates the decay of the Higgs-boson pair, in which one of the Higgs bosons decays to a b-quark pair ($b\bar{b}$) and the other decays to WW^*, ZZ^*, or $\tau^+\tau^-$, with in each case a final state with two b-quarks, two light leptons, and two neutrinos, assessed via missing transverse energy, using 140 fb^{-1} of proton-proton collisions at a center-of-mass energy of $\sqrt{s}$ = 13 TeV recorded by the ATLAS Experiment at the Large Hadron Collider (LHC). Its primary aim is to significantly enhance the sensitivity of the measurement of the non-resonant Higgs boson pair production, based on efficient lepton triggers and a precise analysis of the estimation of signal and background processes. The search results in an observed (expected) upper limit of 9.7 ($16.2^{+8.5}_{-5.3}$) times the Standard Model prediction for the cross-section of non-resonant Higgs boson pair production at a 95% confidence level using full Run 2 data.

The production of SM HH, though, is an extremely rare process, with an expectation of only around 4,000 events throughout the entire Run 2 operation, compared with the production of a single Higgs boson estimated to be more than 8 million over the same period. The prospect of observing HH production and better constraining the Higgs boson self-coupling is expected to be improved at the LHC Run 3 and High-Luminosity LHC (HL-LHC) which plans to increase the peak luminosity of $p\,p$ collisions by a factor of five compared to the Run 2 operation, and eventually deliver 3000 fb^{-1} of integrated luminosity at $\sqrt{s}$ =14 TeV. With this increased luminosity leading to radiation damage, and higher data rates, the current ATLAS tracking detector will become unusable for the HL-LHC. Therefore, ATLAS scientists are actively developing a new device called the Inner Tracker (ITk) to replace the current tracker. The ITk system is an all-silicon detector with a small-radius pixel detector and a multi-layer strip detector wrapped around it.

My presentation is structured as follows: The first part is about the study of Higgs boson pair production, in particular in the bbll final state, where I will show the results obtained with the full run 2 data as well as the ongoing R&D efforts for this analysis with the ongoing Run 3 data collection. In the second part, I will highlight my involvement in the ITk project at BNL, focusing on the ITk Strip Detector Module Testing.

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